Chapter 5
BRIDGING

Military traffic engaged in rapid movement on the AirLand battlefield must be able to cross wet or dry gaps in existing road networks or natural high speed avenues. Bypasses and fording sites can be used to overcome obstacles when no bridges are available. However, maneuver forces and logistical support depend upon permanent, expedient, or tactical bridges for sustained mobility. As the battle moves forward, MSRs are extended to support the force. Forward elements may demand that expedient, nonstandard structures replace assault tactical bridging. In-place bridging may need to be repaired or reinforced to keep MSRs and LOCs open.

Engineer units in support of maneuver forces are responsible for employing assault and tactical bridging. Field Manual 5-101 addresses engineer bridging support to maneuver units. Reinforcement and repair of in-place bridging is generally carried out by engineer units operating within the corps and COMMZ areas.

FIXED BRIDGING

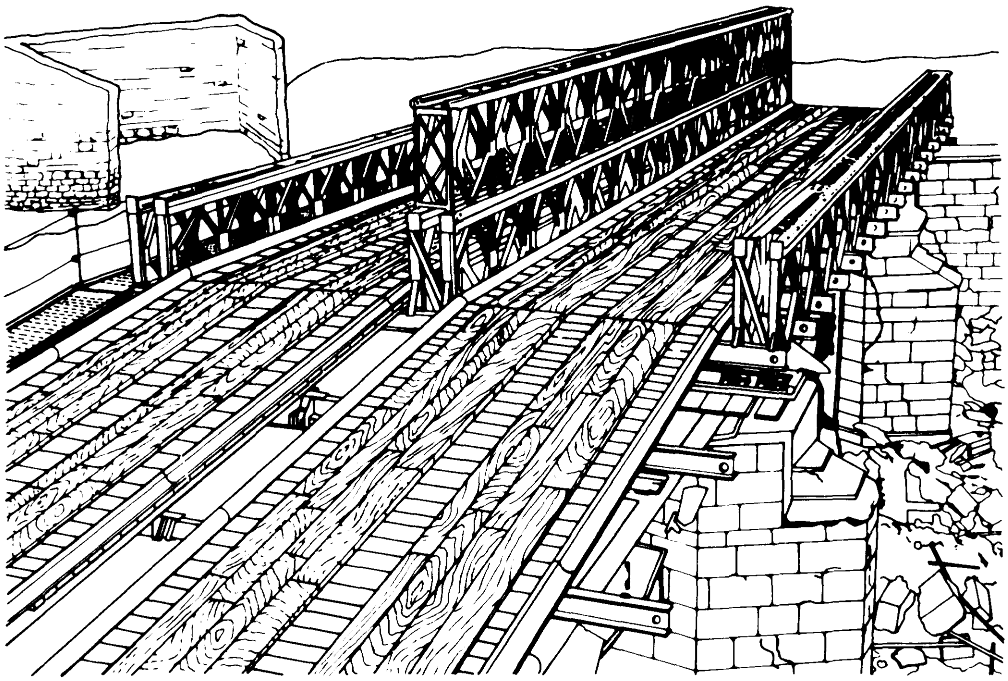
Fixed bridging in the Theater of Operations is classified as standard or nonstandard. Standard military fixed bridges are stock items, organic to engineer fixed bridge units (see FM 101-10-1 for details), or available for issue through the US Army supply system. Fixed bridge assets may be held in reserve at the corps or theater level.

Fixed bridges consist of standard component parts which are assembled in a standard sequence to carry predetermined loads. These may be assault (Armored Vehicle Launched Bridge (AVLB) and Ribbon), tactical (Bailey, Medium Girder Bridge, M4T6), or semipermanent (beam and girder) bridges. The Army Facilities Components System (AFCS) lists several varieties of fixed bridging available in standard sets. Descriptions and construction techniques are discussed in TM 5-312. Nonstandard bridges may be constructed out of whatever suitable material is available. New construction is usually limited to short, simple span arrangements of timber or steel stringer construction. In the Theater of Operations, it is better to repair or reinforce existing nonstandard bridges than it is to undertake new construction.

FIXED BRIDGE SITE SELECTION

Reconnaissance of existing bridges

Bridge reconnaissance is a means of evaluating the physical details of existing bridges. The reconnaissance team inspects the bridge to determine its load-carrying capacity (classification) and its structural well-being. The reconnaissance team should determine whether the situation warrants constructing a nonstandard bridge or emplacing tactical bridging. When a damaged bridge is to be replaced, reconnaissance information should include a report on the serviceability of in-place structural members and other materials which might be reused in construction. Maximum use should be made of existing bridge sites to take advantage of existing roads, abutments, piers and/or spans that are serviceable.



BAILEY BRIDGE SPAN OVER DEMOLISHED MASONRY ARCH BRIDGE

Bridge reconnaissance is classed as either hasty or deliberate, depending on the amount of detail required, the time available, and security in the area of operations. Both kinds of reconnaissance are fully discussed in FM 5-36. A deliberate reconnaissance is usually conducted in support of MSR/LOC operations, since greater traffic requirements dictate that time and qualified personnel be made available to support the task. A deliberate reconnaissance includes a thorough structural analysis and reports on approaches, the nature of the crossing, abutments, intermediate supports, bridge structure, repair and demolition information, and alternate crossing sites.

Reconnaissance for new construction
The two primary tasks of the reconnaissance are to choose a site and to provide enough information so that planners can design a structure that will support the maneuver units' mission.

The location chosen for the bridge by the reconnaissance team is determined by several factors, which are reflected in its structural design.

Ž Location of an existing road net with respect to the proposed site. Time may be saved if approaches to the bridge site are adequate.

Ž Availability of serviceable abutments and intermediate supports from a demolished bridge.

Ž Characteristics of the existing channel which may restrict intermediate support construction or may necessitate minimum clearance for navigation purposes.

Ž Soil or rock profile of the streambed, which affects the type and position of bridge supports.

Ž Flow characteristics, including stream velocity, seasonal water depth, and high water mark.

Ž Stream width and bank characteristics, which establish material requirements and position of abutments.

Ž Site restrictions such as existing structures may influence location of the centerline.

Ž Availability of construction resources. Labor and equipment may consist of host nation support, contract construction support, troop construction, or any combination thereof. Sources of construction materials include standing timber, nearby demolished buildings or bridges, local markets, and engineer stocks.

Ž Topographic information. A detailed study of the proposed site is developed using topographic, geologic, and terrain maps, and air photos as available or required. Stereo-pair air photos with a scale of 1:20,000 or smaller are particularly useful for a map study of possible bridge locations, since they usually indicate stream conditions, including channel location and bar positions. Frequently, a reasonably accurate estimate of soil conditions on the banks can be made from air photos.

Ž Location of a bivouac site and a preconstruction storage area.

SITE STUDY

Following selection of a bridge site based on reconnaissance, both by map and actual observation, detailed planning and study are undertaken to—

Ž Prepare a topographical map to a scale of approximately 1:250 with a contour interval of 2 feet. The map is used to plot location and obtain distances and elevations for design purposes.

- Determine whether physical characteristics at the site limit normal construction methods or interfere with construction plant installation.

- Make a detailed survey to furnish accurate information from which the bridge layout can be developed, materials requisitioned, and the construction procedure outlined. Submit the survey as plan and profile site drawings. Show subsurface conditions graphically. Technical Manual 5-312 discusses survey drawing requirements for fixed bridges.

- Establish survey control. The complexity of the bridge construction project usually determines the appropriate method and accuracy requirement for survey control (TM 5-312, Chapter 12). Surveyors can usually rely on a line strung between the centers of the proposed abutments for a timber trestle bridge. However, they should emplace an accurate system of benchmarks before constructing semipermanent bridges. This ensures accurate lateral positioning of piers, abutments, and stringers, and establishes vertical control so that bearings and pier tops can be located accurately.

- Conduct a foundation investigation. Develop a soil profile along the proposed bridge centerline and at pier and abutment locations (TM 5-312, Chapter 2).

MAJOR ELEMENTS OF FIXED BRIDGE DESIGN AND CONSTRUCTION

Height of bridge

The necessary height of the bridge is governed by the relative height of the bridge ends with respect to that of the ground profile at points below the bridge. Do only as much excavation as needed so that the footings of intermediate supports can be placed on soil capable of carrying the bridge loads. Provide clearance for vessels if the stream must be kept open to navigation. Provide enough clearance to prevent the superstructure from being damaged by current or by floating debris. If possible, select standard pier designs to meet all these conditions.

Span length

Standard designs for various span lengths are available. Fit standard designs to ground and stream profile conditions. Select a combination of span lengths that locates intermediate supports where there is adequate soil bearing capacity for footings, and where piers of standard height offer the least obstruction to the current. Place intermediate supports where footings will not be undermined by erosion. If footings are not possible, consider using piles for supports.

Design loads

Loads are classified as live (vehicles, wind, snow), dead (weight of the bridge and accessories), and impact (short duration loads caused by sudden acceleration and braking action of vehicles on the bridge roadway).

MATERIAL AND LABOR REQUIREMENTS

Make the best possible use of materials on hand, and adapt the design to available materials. The construction site's proximity to materials is important. Assess time and transportation needed to bring materials on the job.

Select a standard design that can be built with available skills and equipment. Engineer troops are trained to use carpentry tools in framing timber. Concrete can be mixed and placed by ordinary field construction labor, provided adequate and experienced supervision is available. Timber bridges can be erected with organic equipment and without power equipment, if necessary. In fabricating structural steel, such work as template making, laying out, cutting, drilling, riveting, and welding require special training. Handling and erecting steel members require heavy equipment. Erecting long spans, particularly on high towers, is hazardous. Therefore, only well-trained and properly equipped crews should undertake this work. Use skilled labor to construct concrete forms, place reinforcing steel, and finish concrete.

FLOAT BRIDGING

Military float bridging is designed to provide maneuver forces with assault (Ribbon Bridge) and tactical (CL60, M4T6, Light Tactical Raft) wet gap crossing capability. Float bridging is organic to Corps and Divisional Engineer Float Bridge Companies (see FM 101-10-1 for details) or maybe held in reserve at corps or theater level. These bridges consist of standard end and interior bay sections which are self-buoyant, or consist of decking affixed to pontons. Descriptions and construction techniques are found in TM 5-210.

Main supply routes use fixed bridging when it is available. Float bridging may be used under some circumstances. For instance, the lack of existing fixed facilities or suitable construction materials to fabricate/reinforce/repair fixed bridging, or the urgent need to maintain logistical flow may dictate temporary military float bridging. When the situation calls for prolonged use or heavy traffic, an existing fixed bridge should be upgraded or new construction initiated.

FLOAT BRIDGE SITE SELECTION

Criteria for establishing a float bridge site are generally the same as those for fixed bridge sites. The following are additional considerations:

- Banks should be low, firm, moderately sloping, and free from obstructions. Existing or easily prepared assembly sites are desirable.
- Water adjacent to the near bank should not be more than waist deep. Current velocity should be moderate (less than 11 feet per second).
- Water depth must be sufficient to prevent boats or bridge components from running aground.
- Natural holdfasts for anchorages are desirable.

Float bridging must be installed far enough downstream from a demolished or under capacity bridge to avoid interference with reconstruction or reinforcement operations. Unstable portions of a demolished bridge and debris that may damage the float bridge should be removed.

RAILROAD BRIDGES

United States Army railroad bridging is fixed, and is classified as standard or nonstandard. The US Army does not currently employ railroad float bridge equipment. Many varieties of standard railroad bridges are available through AFCS. Construction details and bills of material are shown in TM 5-302. General information on types and construction procedures or criteria for standard railroad bridging is given in TM 5-312. Nonstandard railroad bridging can be constructed out of any available suitable material. The military situation rarely permits permanent railroad construction, hence semipermanent construction is generally used.

SITE SELECTION

The urgency of the military situation, lack of readily available construction materials, specialized construction equipment requirements, and the need for large quantities of labor, generally preclude the construction of railroad bridges at locations away from existing rail lines. When a site must be selected, use the criteria for fixed highway bridges.

CONSTRUCTION DESIGN

Time, materials, equipment, and labor are major factors in engineer construction operations. The engineer must choose the structure that can be erected most swiftly with the least expenditure of materials and effort. Repair and reinforcement of existing railroad bridges take priority over new construction. New construction is normally limited to trestle bridges of rolled steel beams or built-up girders. Stringer decks—heavy timber for short spans of 16 feet or less—or steel stringers for longer spans, are the easiest to construct in the field. Design criteria for nonstandard railroad bridges are contained in Chapter 8 of TM 5-312 and civil design texts listed in Appendix A of TM 5-312.

CONVERSION OF RAILROAD BRIDGES TO HIGHWAY BRIDGES

The urgency of the situation, or lack of additional highway bridging assets, may require that a railroad bridge be converted into a highway bridge by constructing a smooth roadway surface. However, the use of the bridge for rail traffic should not be jeopardized. The use of the bridge by both modes of transportation can be achieved by constructing planking along the ties between and outside the rails up to the level of the top of the rail. The roadway surface is thus flush with the top of the rail. The additional dead load of roadway decking must be factored into the bridge classification to determine safe traffic loads. More information may be found in TM 5-312, Chapters 8 and 10. Since railroad loadings are usually heavier than highway loadings, it is seldom practical to convert a highway bridge to railway use.

BRIDGE CLASSIFICATION

An efficient MSR network must be able to carry all expected traffic loads. Often, bridging is the weak link in the load-carrying capacity of a route. Military standard bridging is designed to be assembled in modules that result in a bridge of known capacity. Tactical bridging is designed to pass an uninterrupted flow of combat/tactical vehicles, which generally fall within a military load classification (MLC) below 60. However, some combinations of vehicles may exceed a given bridge design capacity. Where heavy loads are anticipated, it is best to plot MSRs along routes that already use bridges with appropriate classification ratings, or to design and emplace bridges that can carry these loads.

Situations may arise when it will be impossible to safely accommodate all traffic designated to cross MSR bridges. Guidelines are set for special crossings (caution and risk) for oversized or overweight loads on military fixed and float bridging (FM 5-34, FM 101-10-1, TM 5-312, TM 5-210). The theater commander may authorize such crossings. An engineer officer must periodically inspect the bridge for signs of failure when routine caution crossings are made and after each risk crossing. Structurally damaged parts must be replaced, repaired, or reinforced before traffic can be resumed.

In addition, not all civil-installed bridges are designed to support military MSR traffic. Load classification may not have been determined by civilian authorities. Many kinds of bridges may be encountered in the Theater of Operations, and there is no single easy approach for classifying them. Some bridges, such as simple stringer bridges, can easily be classified by their external dimensions. However, it may be impossible to calculate a reasonable classification for other types, such as prestressed and continuous span concrete, unless complete design information is available. The most reliable index for classifying such a bridge would be an analysis of the floor system. The Theater Engineer must set policy on caution and risk classifications for civil-installed bridges, while the Theater Commander retains authorization for these special crossings.

When faced with a special crossing situation, always consider alternatives like bypasses and fords. Measure the importance of oversized or overweight traffic against other traffic using the bridging. Forward movement of combat power and logistics takes precedence over evacuation and retrograde movement.

METHODS

There are two methods of classifying a bridge: analytical and expedient. Careful analysis must often follow expedient classification. The situation and available time and information determine the method chosen. An analytical classification may be required if the bridge is of great importance. An engineer's estimate may suffice if similar bridges in the area have a known classification (see FM 5-34 and TM 5-312).

SOURCES OF EXISTING INFORMATION

Bridge classification data can usually be found with the local engineer unit. This unit is responsible for the area where the bridge is located along with the supporting topographic engineer unit. If the bridge was constructed by military engineers, the design class or as-built plans should be on file. Engineer intelligence studies often provide bridge classification information for most areas of operation in foreign countries. Classify the bridge using engineer reconnaissance data.

The most reliable source of bridge classification information for civilian-constructed bridges is local civilian authorities. In most cases, complete design specifications, as-built plans, and the types and strengths of materials used in civilian bridges are available.

Local, state, and county officials in the United States and in friendly foreign countries often impose maximum load limits or maximum permissible stresses on their bridges. It is important that these officials be consulted to determine maximum military load classification that can be applied to the bridge in peacetime or for maneuver purposes. Corrosion and normal wear and tear tend to diminish a bridge's load-carrying capacity over time. The most recent evaluation of the bridge is desirable. Based upon the engineer's evaluation of civilian reports, additional appraisal of a bridge's classification may be required.

Correlation curves have been developed for some standard US- and foreign civilian-made bridges that relate the known civilian bridge design loads to military classifications. These curves, discussed in TM 5-312, Chapter 5, are often useful in establishing a temporary bridge classification. The analytical method is always preferred when time and information are available.

RESPONSIBILITIES

Bridge classification and marking is an engineer responsibility. The responsible engineer organization in the area will classify bridges of military significance by the analytical method if possible. If a posted temporary class is judged accurate by the responsible engineer, the classification can be posted as permanent. Engineer units should keep records on each significant bridge within their assigned area.

REINFORCEMENT AND REPAIR

Bridges in the Theater of Operations maybe damaged or may be below the load-carrying capacity required for use on an MSR or LOC. These bridges can be reinforced or repaired by theater engineers. Bridge reinforcement can increase the structure's load-carrying capacities by adding materials to strengthen the component parts, or by reducing span length. Bridge repair, on the other hand, means restoring a damaged bridge to its original load-carrying capacity. Reinforcement or repair of existing bridges or sites has many advantages, chiefly economy of time and material. Existing bridges are located on established routes, which require less work on approaches and speed the flow of traffic. The availability of serviceable bridge components, particularly abutments and piers, conserves both time and materials.

BRIDGE REINFORCEMENT

Capacity

Tactical loads may exceed the capacity of the existing structure or the bridge may be damaged or deteriorated with use. Well-designed reinforcement usually increases the life of the bridge.

Maintenance reduction

Bridge reinforcement at selected sites can serve to shorten the route and decrease attendant vehicle maintenance problems. When smooth deck surfaces can be provided, the movement of traffic is further expedited. Maintenance to bridge structural members is reduced as stress is decreased through reinforcement.

Release of tactical bridging

Reinforcement of existing bridges may permit the release of tactical bridging, although the use of M2 (Bailey) panel bridge components is often necessary for expedient reinforcement purposes. However, other types of tactical bridging including both fixed and floating types may be released.

Weather

The necessity for reinforcement measures may be dictated by increased stream flow during the rainy season, when bypasses and fords are impassable. Such conditions must be anticipated to effect timely reinforcement measures.

Construction factors

Once the decision has been made to reinforce a given bridge, several construction factors must be taken into consideration before detailed planning and execution may be undertaken. Among these factors are details of the site, available materials, and possible construction methods. Pertinent questions concerning the site include— What parts of the original structure are still usable? What is the type of bridge and what are the span lengths? What are the characteristics of the waterway, particularly as to the use of additional bents or pile piers? Will the present approaches be satisfactory for a reinforced bridge? Will the intermediate supports and abutments also need to be reinforced? Are alternate sites available?

Materials that may be used include standard steel military units (preferred because of quality and speed of construction), military stock timbers, other military items of issue, local materials of adequate quality. Possible construction methods depend upon items of equipment available, working locations, and the nature of the repairs. A detailed discussion of bridge reinforcement is contained in TM 5-312.

BRIDGE REPAIRS

Emergency repairs are usually governed by the requirement that a crossing site be available as soon as possible. Immediate need dictates the desired capacity and permanence of the structure. Where possible, standard units should be used to expedite repairs. Tactical bridging is designed for this purpose. However, in the absence of tactical or standard bridging, expedient methods will satisfy the requirements in many cases. Most emergency structures will later be reinforced, replaced, or rehabilitated. Bridge structures and surroundings, the nature of bridge damage, and the methods of repair are all so varied that no preferred method can be suggested.

Experience with several methods will usually suggest a practical method of repair. Unless there has been an opportunity for advance planning, the selection of repair methods should be left to the engineer commander responsible for the repairs. The factors upon which the engineer will base choices are—

- Type of bridge.
- Nature of damage.
- Tactical situation and bridge requirements.
- Nature of surroundings and immediately usable bypasses.
- Troops and equipment available.
- Standard stock bridging materials and accessories available, and the time involved to get them to the site.
- Local materials available.
- Time estimated for bridge repair versus time estimated for a detour or preparation of a bypass.
- Skill and ingenuity of officers and troops.

A detailed discussion of emergency bridge repair is contained in TM 5-312.

DETOURS AND BYPASSES

Detours and bypasses are second in priority only to the use of existing bridges. Reinforcements and repairs of existing bridges are third in priority. In general, detours and bypasses can be found and used more quickly than existing bridges can be repaired.

Even though railroad detours usually cover greater distances than highway detours, the problem is reduced considerably when an alternate route is available to a serviceable bridge, or to a bridge that can be repaired under favorable circumstances. Detours and bypasses are usually of the following types:

- Alternate routing over other existing bridges which have not been damaged.
- Alternate routing over bridges with lesser damage or routing to other locations.
- Alternate routing of highways over railroad bridges.
- Bypasses with a grade crossing around an overpass.
- Fords.
- Local ferries, rafts, or barges.
- Ice bridges in extremely cold climates.

Consider the condition of existing roads and approaches that connect with detours and bypasses. The work necessary to make roads usable may outweigh the advantages of these alternates. Traffic-supporting properties, grade and alignment, built-up areas, and sharp curves or corners involving clearances are also important factors.